



U.S. Department of Energy's Office of Science

ADVANCED TOKAMAKS **A Brief Introduction**

FY2010 Budget Planning Meeting
Gaithersburg, MD
March 11-12, 2008



Erol Oktay, Acting Director
ITER and International Division

www.ofes.fusion.doe.gov

BPM Presentations are organized along configurations and topics

- Advanced Tokamaks
 - Burning Plasmas – implicit in Van Dam's talk
 - DIII-D
 - C-MOD
- Spherical Tori
 - National ST Program
- Stellarators
 - National Compact Stellarator Program
 - NCSX
- Other Alternate Magnetic Configurations
 - Compact Tori
 - MST
- Enabling R&D
- Plasma Science
- Theory and Simulation
 - Theory Program overview
 - SCIDAC
- International Collaboration
- HEDLP/IFE
 - Heavy Ions
 - Fast and Shock Ignition
 - Magneto Inertial Fusion

What is ADVANCED TOKAMAK

- AT in the FES lexicon since 80's
- Evolution of the tokamak concept over time
- Google search on 'Advanced Tokamaks'
 - Many cached references
 - Kessel presentation to APS in April 2003

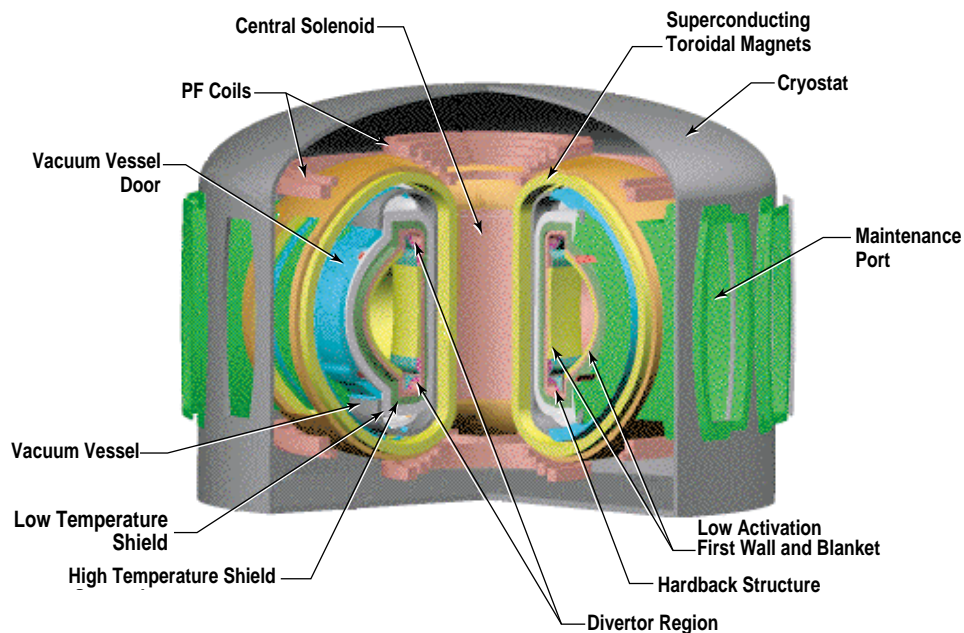
OPTIMIZATION OF THE TOKAMAK CONCEPT LEADS TO AN ATTRACTIVE FUSION POWER PLANT

● Attractive features

- Improved power cycle
 - Improved economics
 - Reduced size
- Higher pressure, reduced heat loss*

	<u>Conventional</u>	<u>Optimized</u>
Power cycle	Pulsed	Steady-state
COE ¢/kWhr	~13	~7
Major radius (m)	8	5

● The U.S. ARIES system study

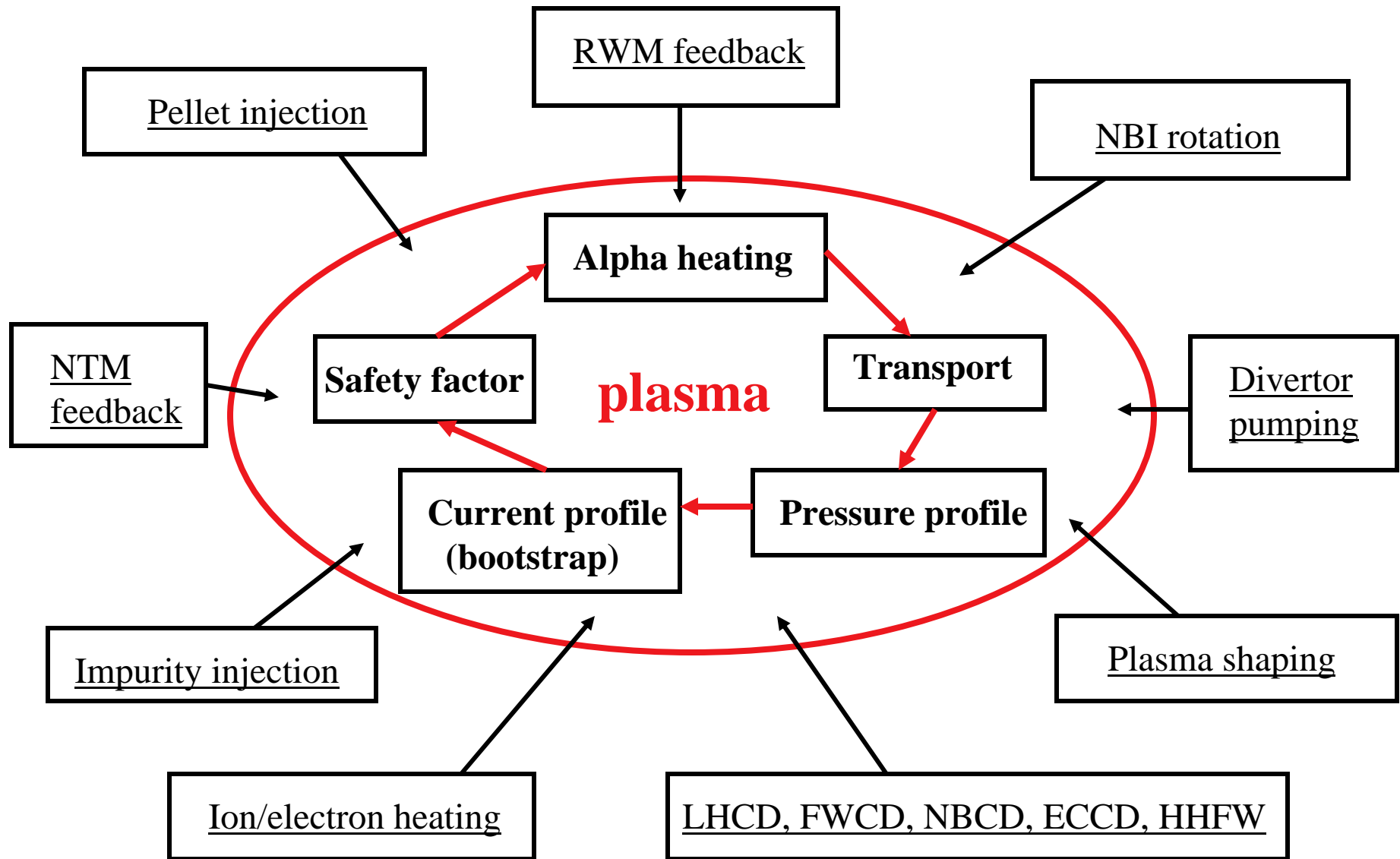


- Optimization of the tokamak concept is known as the Advanced Tokamak program

What is an Advanced Tokamak?

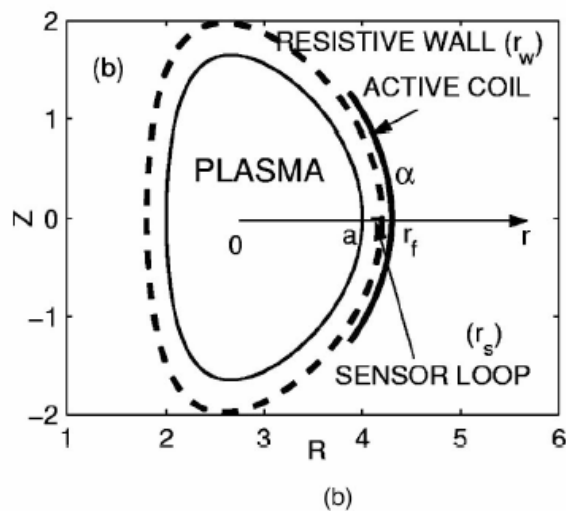
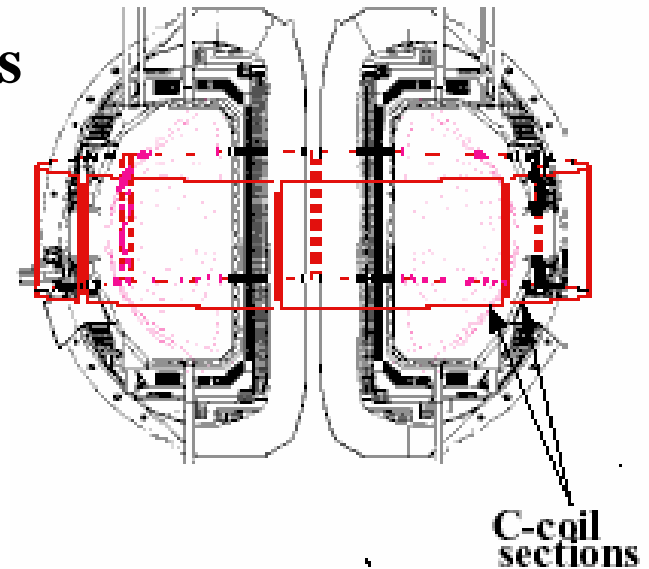
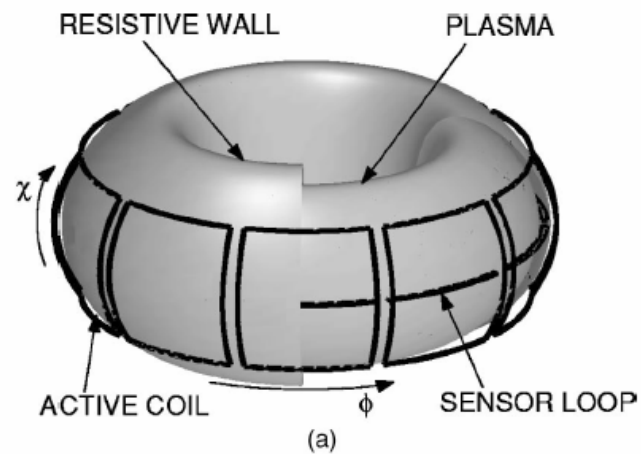
- The advanced tokamak plasma **simultaneously obtains**
 - Stationary state
 - High plasma kinetic pressure ----> MHD stability
 - High self-driven current ----> Bootstrap current
 - Sufficiently good particle and energy confinement ----> Plasma transport
 - Plasma edge that allows particle and power handling ----> Boundary condition between hot core plasma and vacuum/solid walls
- The advanced tokamak is a **recognition** that the tokamak is an **integrated system** and **requires control** to succeed
- The advanced tokamak is a **tough nut to crack**

Appreciating the plasma's integrated behavior is helping
us learn to control it

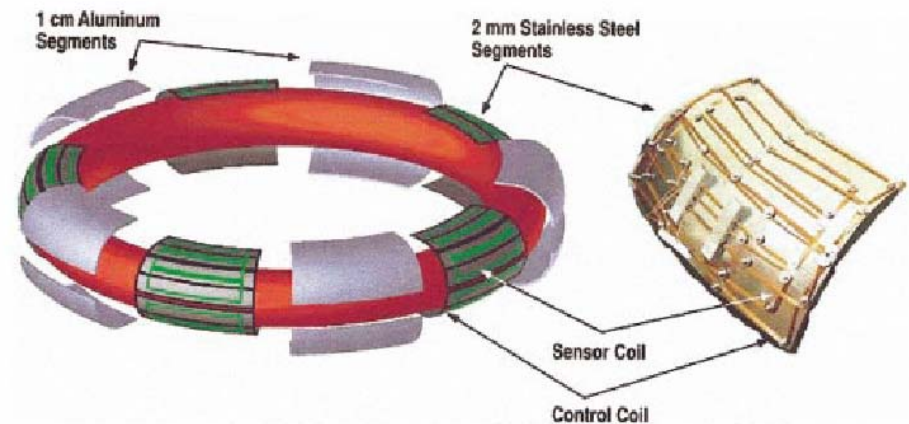


Theory and Experiments Show That **Powerful MHD Instabilities** Can Be Controlled

DIII-D, General Atomics

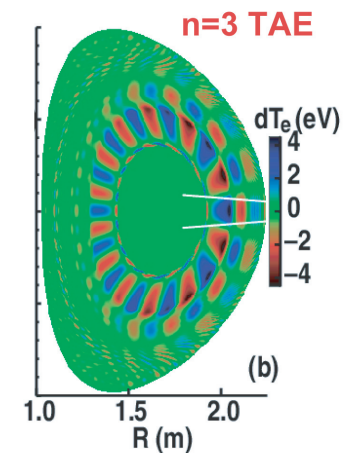
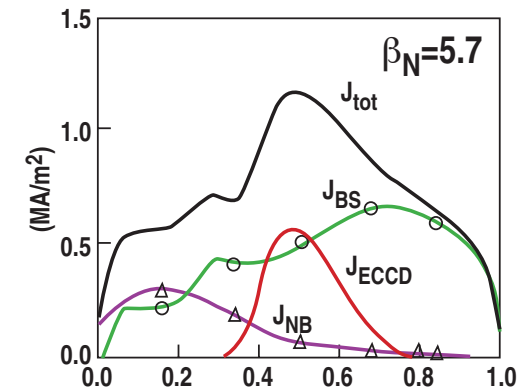
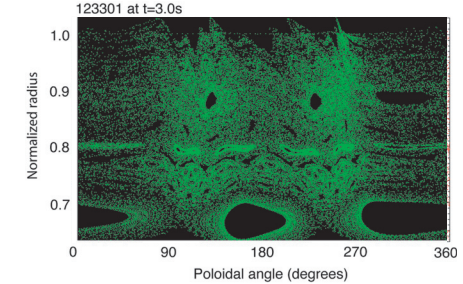


HBT-EP, Columbia Univ.

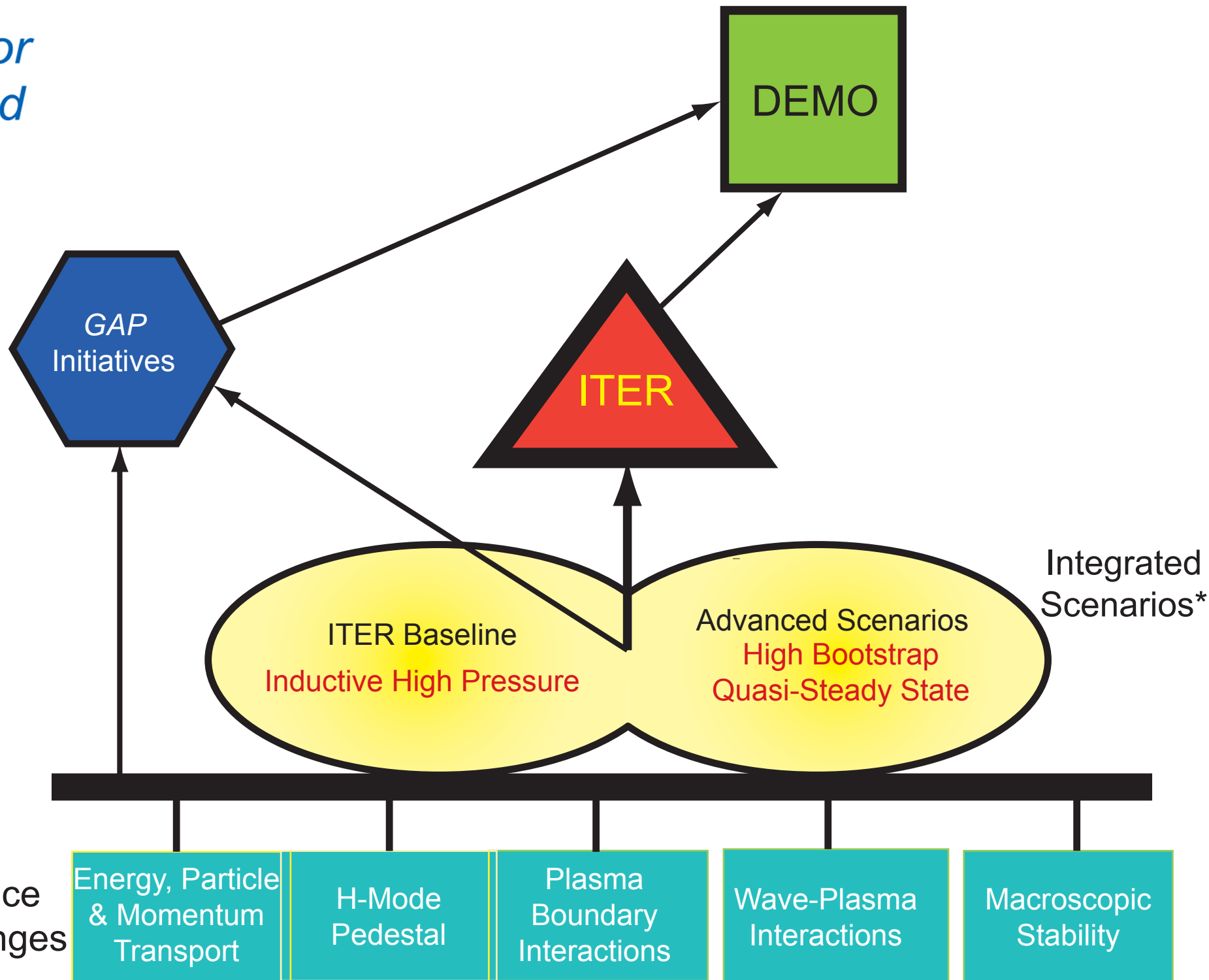


The DIII-D Program Plan has Three Major Goals

- ITER Support: Enable the success of ITER by providing physics solutions to key issues
- Advanced Tokamak: Establish the physics basis for steady-state high performance operation of ITER and beyond
- Fusion Science: Advance fundamental understanding of fusion plasmas along a broad front
 - Validate predictive models



~~Alcator
C-Mod~~



*Equilibrated electrons-ions, no core momentum/particle sources, RF I_p drive

Evolution continues

- ITER long pulse operation based on AT
- AT an explicit program element in DIII-D and C-MOD in the past
- Now has evolved into ‘Advanced Scenarios’
- Presentations from DIII-D and C-MOD
- No presentation for HBT-EP